

ATLAS FLEX HYBRIDS

The University of Oklahoma

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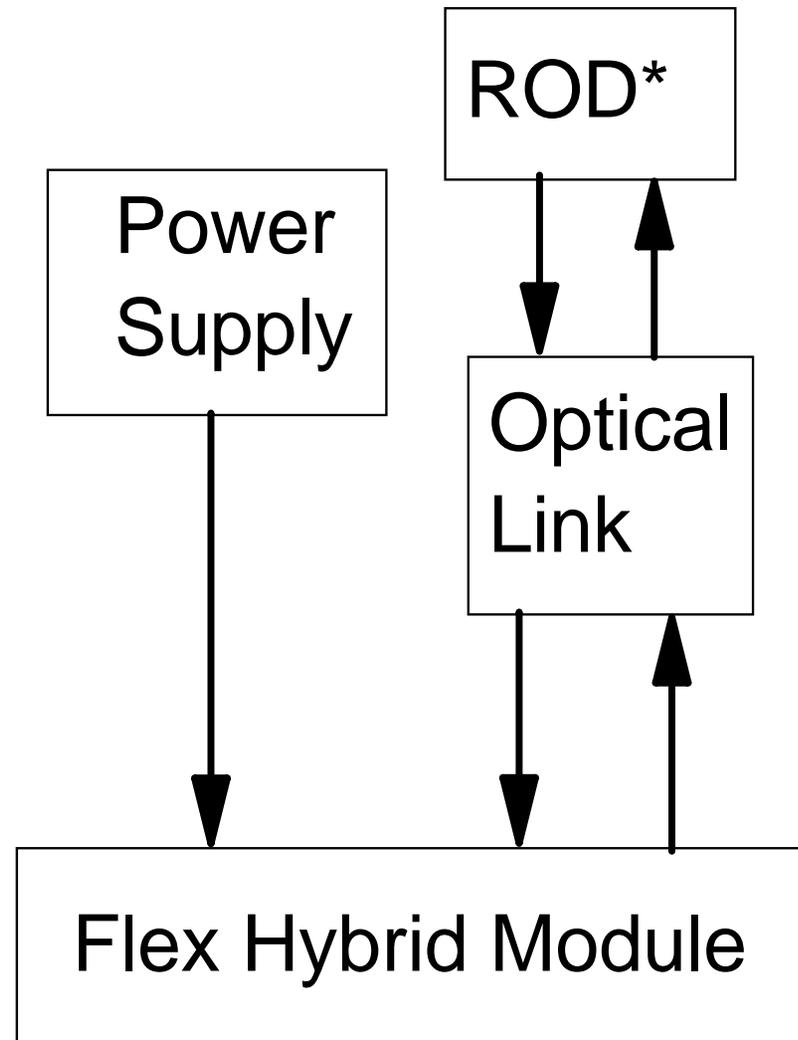
2 November, 2000

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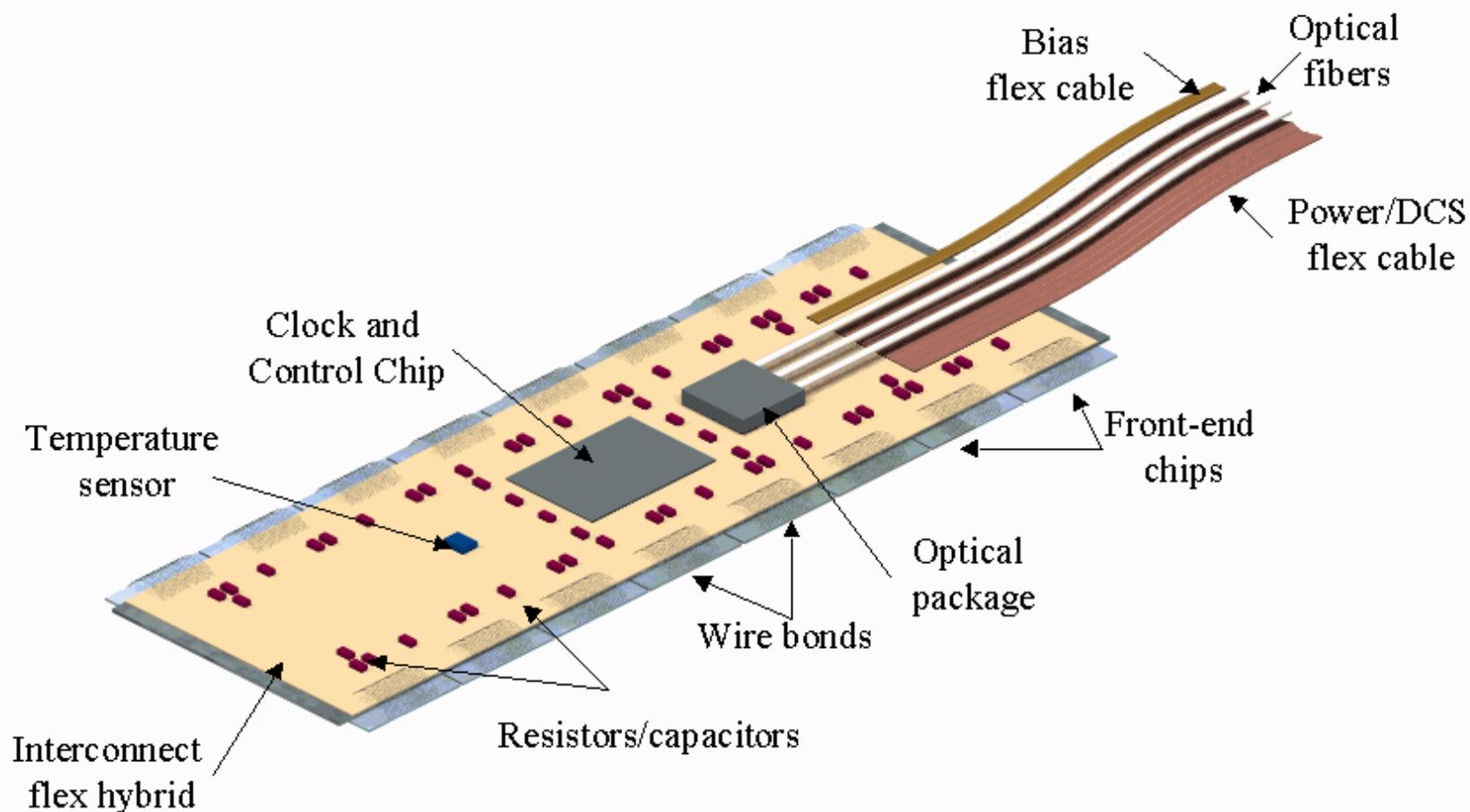
Function

- Provide connection for:
 - ▶ Power
 - ▶ Clock
 - ▶ Data In
 - ▶ Data Out
- Between module and:
 - ▶ Power supply
 - ▶ Optical link



* Read Out Driver

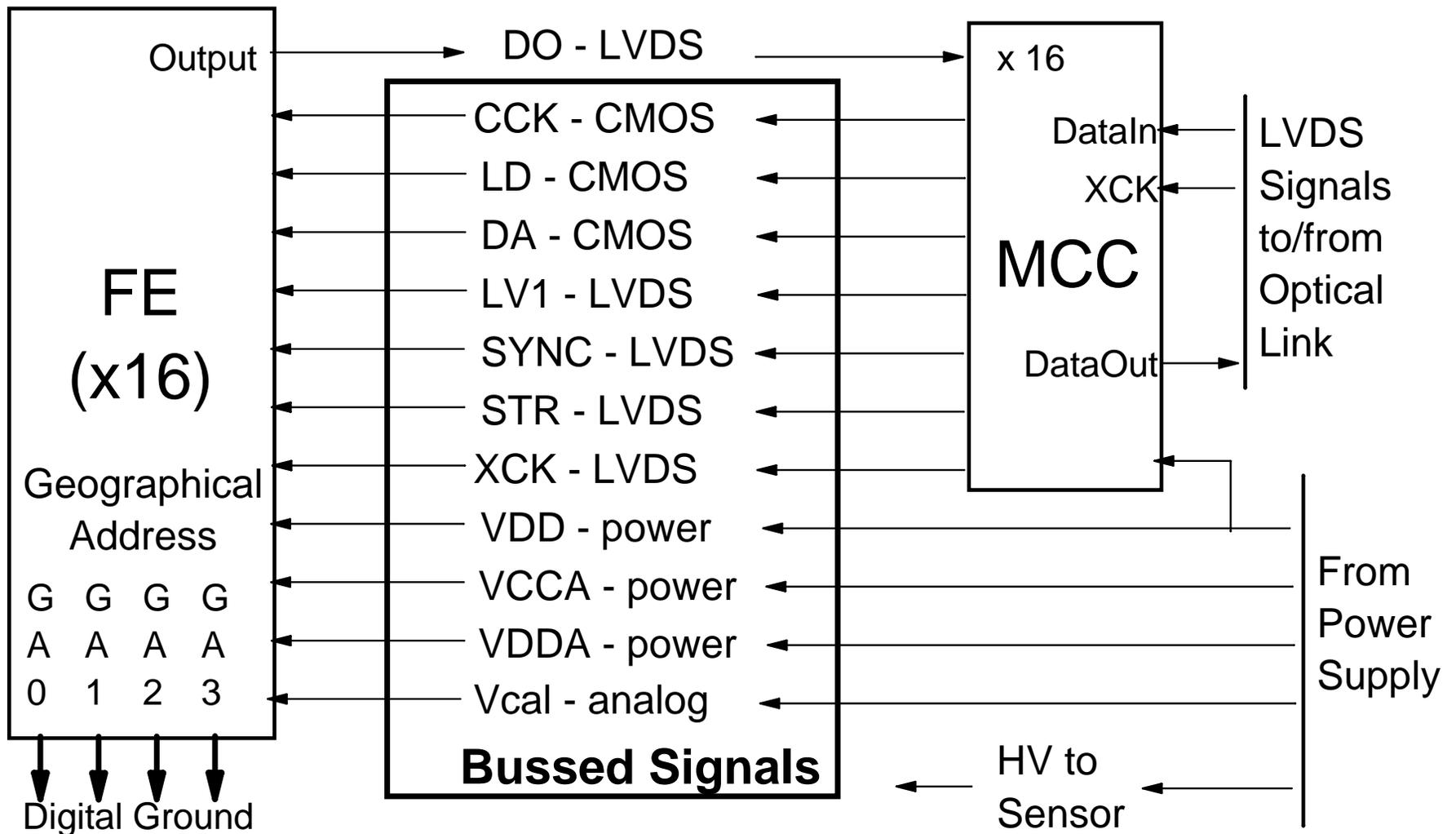
Function (*continued*)



Early Flex Hybrid module concept
Optical link no longer included on module

Function (continued)

- The Flex Hybrid also provides interconnection between the 16 FE's (Front End chips) and the MCC (Module Control Chip)



Specifications (*continued*)

- Flex fabrication specifications
 - ▶ Overall size approx. 86.5 mm x 19.6 mm
 - ▶ Substrate of 25.4 μm polyimide (Kapton or Upilex)
 - ▶ Two metal layers connected by through-hole vias with no break out of via cover pads
 - ▶ Patterned cover layers top and bottom of 25.4 μm Pyralux with placement accuracy of $\pm 125 \mu\text{m}$
 - ▶ Sputtered seed metal (Cr or Ti) on polyimide
 - ▶ 75 μm traces and spaces (less between via cover pads and adjacent trace, depending vendor technology)
 - ▶ 100 μm x 300 μm bond pads with 50 μm space
 - ▶ 15 μm - 18 μm Cu, 1 μm - 2 μm Ni, 0.1 μm - 0.2 μm Au compatible with Al ultrasonic wire bonding
 - ▶ Final dimension tolerance: $\pm 75 \mu\text{m}$

Flex Vendors

- CERN PCB facility
 - ▶ Charge for materials only, but:
 - Two tests required (outside vendor):
 - Before defect repair
 - After Ni/Au plating
 - More expensive shipping (to US)
 - Laser cutting not provided
 - ▶ In house electroless Ni and Au plating
 - ▶ Has fabricated v1.0, v1.1, v1.1, v1.4 and v2.2 flex
- Compunetics (Monroeville, PA)
 - ▶ In house testing (two tests required, also)
 - ▶ Out-sourced Ni and Au plating (has been source of some problems)
 - ▶ Domestic shipping
 - ▶ In house laser cutting
 - ▶ Commercial production facility
 - ▶ Has produced v1.1 and v2.1 flex

Flex Vendors (*continued*)

- Many other potential vendors have been contacted, those that have technology tend to not be interested in small orders (< 100k units), most that will do small orders don't have technology
- R & D Circuits (Edison, NJ): tried for over 1 year
- General Electric Corporate Research and Development (Schenectady, NY)
 - ▶ Built ~600 flex for CLEOIII, Si3 over 2 year period (more aggressive design than ATLAS Pixels)
 - ▶ Limited production capability
 - ▶ More expensive
 - ▶ Dyoconex (Switzerland) and Century Circuits and Electronics (Minneapolis, MN) are other possible vendors

Prototypes

- v1.0
 - ▶ Required support card
 - ▶ Fabricated by CERN in 1998
 - 50.8 μm Kapton substrate
 - No cover layers
 - ▶ Supported FE-A, FE-B, FE-C, AMS MCC
 - ▶ Did not include Vcal
 - ▶ First "working" Flex Hybrid Modules

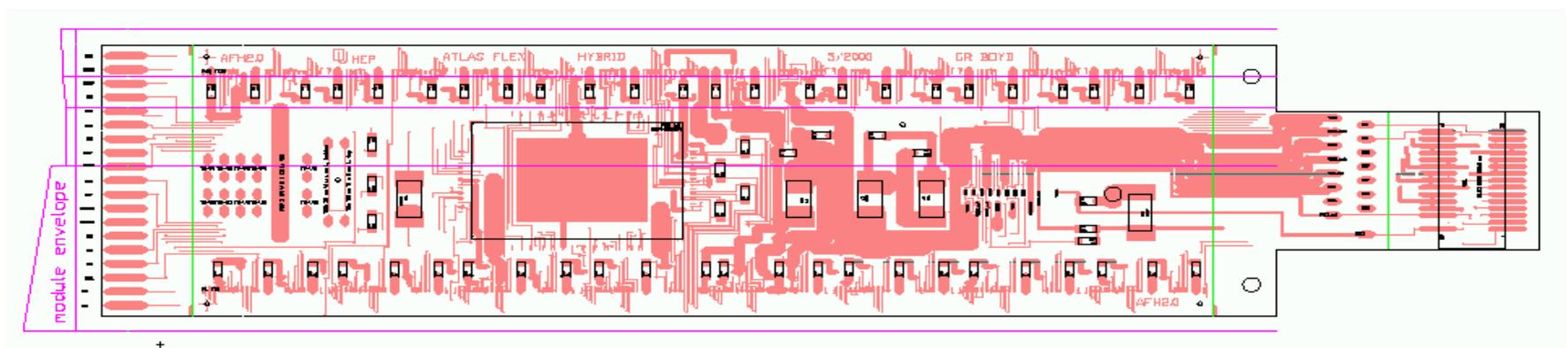
Prototypes (*continued*)

- V1.x
 - ▶ All signals implemented
 - ▶ Improved sensor bias routing
 - ▶ Other routing improvements
 - ▶ Supported FE-A, FE-B, FE-C, AMS MCC
 - ▶ Increased power supply bypass capacitor size
 - ▶ Included test structures coupon for verifying impedance of signal busses, via resistance and trace resistance
 - ▶ Fabricated at CERN and Compunetics
 - ▶ v1.1, v1.4 (only minor routing differences) fabricated at CERN in 1999
 - 50.8 μm Kapton substrate
 - Patterned 60 μm Pyralux cover layers on both sides
 - ▶ v1.3 fabricated at Compunetics in 1999
 - 25.4 μm Upilex substrate
 - Patterned ~ 20 μm Imageflex flexible solder mask on both sides
 - 2.0 μm Au on wire bond pads
 - Intek organic protectant/solder flux on solder pads

Prototypes (*continued*)

■ v2.x

- ▶ Respects barrel module envelope, except FE wire bond pad layout and MCC
- ▶ Wire bond connections for barrel services
- ▶ Solder connections on "tab" for disk services
- ▶ Test connector on "tab" for QA/QC during Flex Hybrid and module assembly
- ▶ Stand alone operational capability but can also be used with support card



v2.x layout showing top traces and barrel module envelope

Prototypes (*continued*)

- v2.x (*cont.*)
 - ▶ Compunetics v2.1 delivered Aug. 2000
 - 25.4 μm Upilex substrate
 - Patterned ~ 25.4 μm Pyralux cover layer on both sides
 - 2 μm Ni, 0.2 μm Au on all traces
 - ▶ CERN delivered v2.2 Sept. 2000
 - 25.4 μm Kapton substrate
 - Patterned 25.4 μm Pyralux cover layer on both sides on 40 pieces
 - Patterned ~ 10 μm Liquid Photo Imagable cover layer on 10 pieces (lower thermal coefficient of expansion than Pyralux)
 - 2 μm Ni, 0.2 μm Au on all traces

Assembly

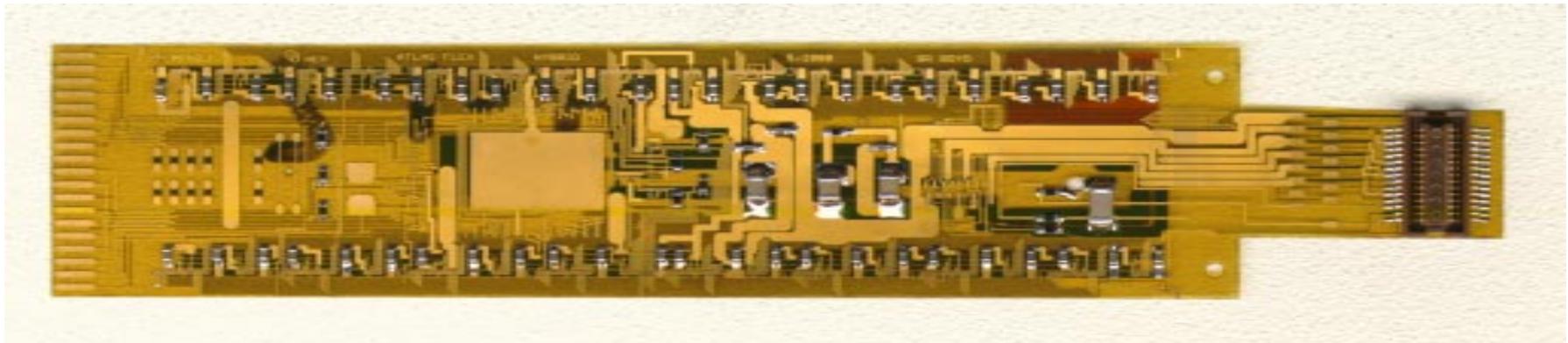
- At present (v2.x) there are:
 - ▶ 51 0402 capacitors
 - ▶ 3 1206 capacitors
 - ▶ 10 0402 resistors
 - ▶ 1 0603 NTC temperature sensor
 - ▶ 1 30 pin connector
 - ▶ 1 MCC - still attached and wire bonded in labs
- Assembly of 1.0 and most of 1.x done in labs
- 10 v1.x assembled at AMA (CA)
- 4 v2.1 assembled at Flex One (CA)
 - ▶ "Dummy" components used
 - ▶ Paste applied through stencil and reflow
- 5 good and 5 electrically bad v2.1 flex assembled at Surface Mount Depot (OK)
 - ▶ Used real components
 - ▶ Hand soldered

Results

- Both vendors have been slow to produce prototypes
- v1.0 Flex Hybrids
 - ▶ Work - two modules built (see Electronics)
- v1.x
 - ▶ 4 Flex Hybrid modules constructed show that v1.x works
 - ▶ Assembly at AMA - minor problems, such as misplaced components, generally good quality work
- v2.x
- CERN delivered 50, Compunetics delivered 41
 - ▶ Test coupons good on electrically good flex
 - Indicates via resistance of $\sim 10 \text{ m}\Omega$
 - Other tests performed, but results yet to be compiled
 - ▶ Some variability of wire bonding results on v2.1
 - Bond pad lift off on electrically bad flex (show evidence of over etching)
 - Results good on good flex when cleaned first (Bonn), inconsistent pull strength (LBL)

Results (*continued*)

- v2.x (*cont.*)
 - ▶ Assembly
 - Surface Mount Depot
 - Solder quality good, parts clean, labeled for tracking
 - Component placement good, but not flush to surface everywhere
 - Two flex "ruined" by solder on bond pads
 - Flex One
 - Solder quality good and parts clean
 - Component placement good (height unknown)
 - Some solder seepage under cover layer
 - Solder flowing onto sensor bias bond pad



v2.1 Flex Hybrid assembled by Surface Mount Depot, less MCC

Results (*continued*)

■ Irradiation

- ▶ First irradiation of resistors, ceramic capacitors and flex with ^{60}Co gamma to 30 Mrad show no significant changes, but samples were small
- ▶ Irradiation at CERN June, 2000, to full fluence (x) of resistors, ceramic capacitors and flex
 - Capacitors show no catastrophic failure (large value changes, shorts), but analysis not complete
 - Analysis of resistors and flex not complete
- ▶ Devices irradiated by ^{60}Co to 60 Mrad not yet analyzed

Results (*continued*)

- Remaining to be done
 - ▶ Complete electrical tests on v2.2 flex (Europe)
 - ▶ Test bottom cover layers for pinholes
 - ▶ More components submitted in October irradiation run at CERN to settle some ambiguities in first CERN run - test and analyze data
 - ▶ Further assembly tests at Surface Mount Depot (stencil and jigs to be built) and Flex One (underway)
 - ▶ Next prototype design - 3.x
 - Awaiting bond pad layout for FE-I and MCC-(?)
 - Final position/pinout of barrel and disk services connections
 - 32 pin test connector for greater isolation of detector high voltage
 - ▶ Final design - optimize power routing for known current requirements

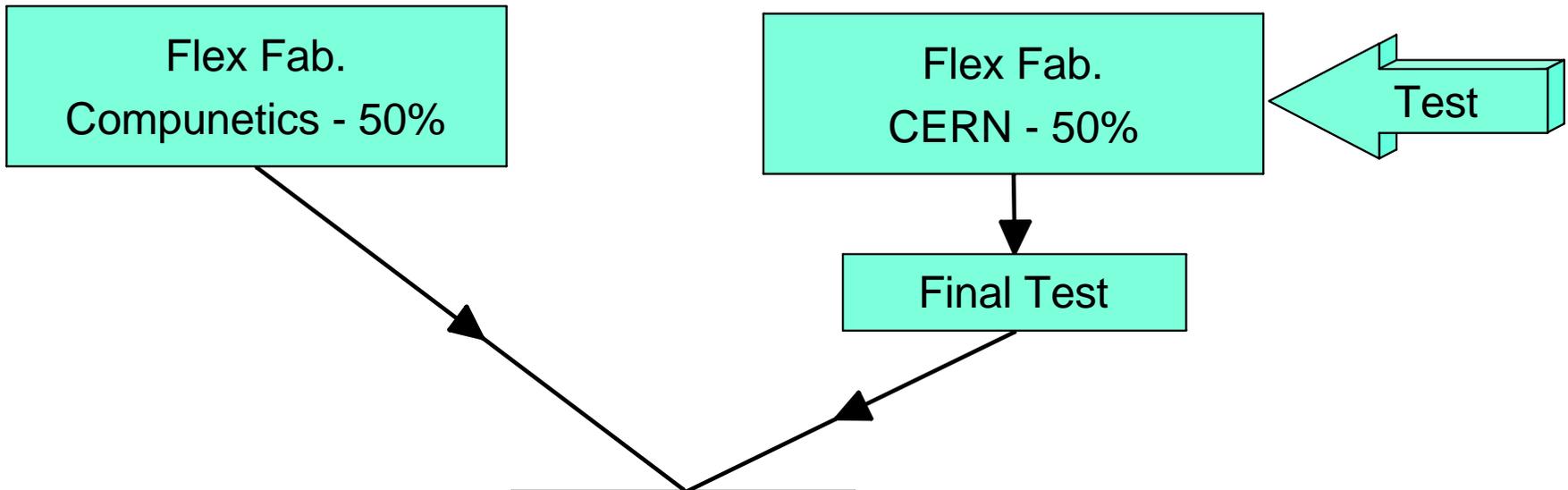
Production

- Deliverables (UOK)
 - ▶ Layout of prototype and final designs
 - ▶ Simulations of flex hybrid power traces and decoupling
 - ▶ Flex Hybrid test design
 - ▶ 100% Flex Hybrids
 - 50% at CERN, 50% at Compunetics
 - All components mounted except MCC
 - ▶ Attachment & wire bonding 50% MCC's
 - ▶ Testing of 50% of Flex Hybrids in US (+Albany)

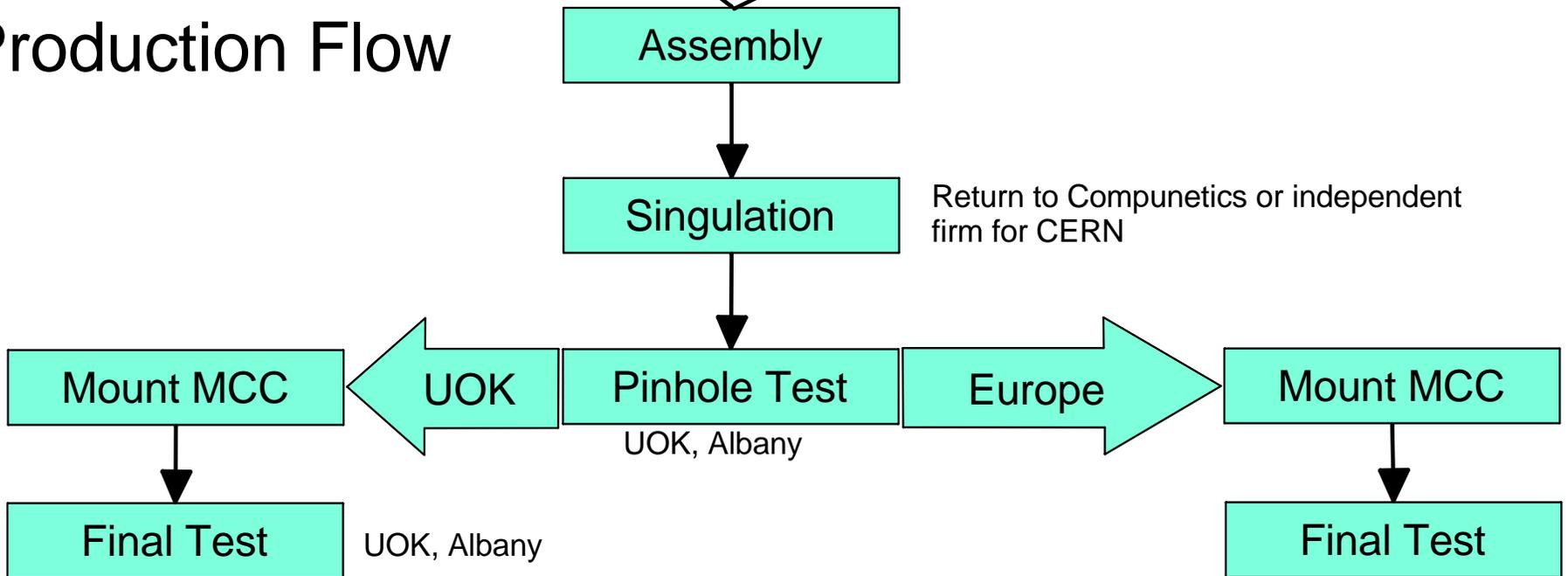
Production (*continued*)

- Flex fabrication
 - ▶ Compunetics - 200 flex/week after "ramp up"
 - ▶ CERN - 200 flex/mo.
- Assembly of components onto Flex Hybrids
 - ▶ Entire production can be done in less than one week with automated pick & place (including part tolerance verification)
 - ▶ Assembly in panel - singulation afterwards at Compunetics and outside vendor for CERN (Spectralytics used for CLEOIII, Si3)
 - ▶ Attachment and wire bonding of MCC (UOK) - estimate 16/day
- Testing
 - ▶ CERN flex tests at Microcontact (Switzerland)
 - ▶ Test for pinholes in bottom cover layer
 - ▶ Test of complete Flex Hybrid
 - C - F test of power busses
 - Functionality test with Genova MCC/Hybrid test stand

Production (*continued*)



Production Flow



WBS	Task Name	2001			2002			2003			2004			2005		
		tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
1.1.1.4	Hybrids/Optical Components	[Summary bar]														
1.1.1.4.1	Design	[Summary bar]														
	Flex 2.x Test Analysis	[Task bar]														
	Flex Hybrid FDR	12/15														
	Flex 3.x Design	[Task bar]														
	Flex Preproduction Design	[Task bar]														
	Release Flex Bids	[Task bar]														
	Flex Bid Evaluation Complete	4/5														
	Flex Hybrid PRR	5/17														
	ATLAS PM Approval of Flex Proc	6/14														
	Award Flex Contracts	6/28														
		7/12														
1.1.1.4.2	Development Prototypes	[Summary bar]														
	Flex 3.x Fab and Test	[Task bar]														
1.1.1.4.3	Production	[Summary bar]														
	Start initial production buy of components	12/13														
	Outer Flex Hybrid (Pre)Production/Load	[Task bar]														
	First outer flex delivered	11/1														
	Outer flex testing	[Task bar]														
	First outer flex available for module assembly	1/24														
	Need date for first outer flex	7/22														
	Outer flex testing complete	10/17														
	B-Layer Flex Hybrid (Pre)Production/Load/Test	[Task bar]														
	First B-Layer flex delivered	10/17														
	First B-Layer flex available for modules	1/9														
	Need date for first B-layer flex	3/16														
	B-Layer flex testing complete	11/28														

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U.S. ATLAS E.T.C. WBS Profile Estimates

Funding Source: All

Funding Type: Project

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Institutions: All

WBS Number	Description	FY 96 (k\$)	FY 97 (k\$)	FY 98 (k\$)	FY 99 (k\$)	FY 00 (k\$)	FY 01 (k\$)	FY 02 (k\$)	FY 03 (k\$)	FY 04 (k\$)	FY 05 (k\$)	Total (k\$)
1.1.1.4	Flex Hybrids/Optical Hybrids	0	0	0	0	0	110	258	422	0	0	790
1.1.1.4.1	Design/Engineering	0	0	0	0	0	18	50	9	0	0	77
1.1.1.4.1.1	Prototype design	0	0	0	0	0	18	0	0	0	0	18
1.1.1.4.1.2	Production design	0	0	0	0	0	0	50	9	0	0	59
1.1.1.4.2	Development and Prototypes	0	0	0	0	0	92	62	0	0	0	154
1.1.1.4.2.1	Flex hybrids	0	0	0	0	0	35	10	0	0	0	45
1.1.1.4.2.2	Optical prototypes	0	0	0	0	0	41	41	0	0	0	82
1.1.1.4.2.3	Pigtails prototypes	0	0	0	0	0	16	11	0	0	0	27
1.1.1.4.3	Production	0	0	0	0	0	0	146	413	0	0	559
1.1.1.4.3.1	Flex hybrid	0	0	0	0	0	0	136	251	0	0	387
1.1.1.4.3.2	Pigtails	0	0	0	0	0	0	0	33	0	0	33
1.1.1.4.3.3	Optical hybrids	0	0	0	0	0	0	10	130	0	0	140